GAMIFICATION, XR LESSONS, AI AND HISTORY TELLING AS ENGINE IN THE LEARNING PROCESS IN HIGHER EDUCATION

Verónica SAAVEDRA GASTÉLUM[1], Carlos Alberto GONZÁLEZ ALMAGUER[1], Natalia FRÍAS REID[1], Anders BERGLUND[2], Guillermo MONTERO[3], Rommel PACHECO[1], and Juan Manuel MURILLO[1]
[1]Tecnologico de Monterrey, Mexico
[2]Mälardalen University, Sweden
[3]Universidad de Sevilla, Spain

ABSTRACT
Emerging technologies have become the engine that accelerates student learning in higher education, combined with educational innovations based on gamification and an appealing storytelling approach to learning complex and usually tedious concepts for students. Students are achieving excellent results in the teaching-learning process, as reflected in the development of their skills. This work continues research presented at E&PDE 24, focusing on AR and VR lessons for engineering students' learning. We present the deployment of these technologies in different training units at the Tecnológico de Monterrey, the University of Seville, and Mälardalen University. In this research, we present a systemic vision of the deployment of a global classroom, which involves real-time interaction among students and teachers from different universities to develop common competencies through the solution of an academic challenge. Design of experiments and design thinking methodologies are applied to prepare for the class activity and measure the effect on students through three variables: engagement, competency development, and learning.

Keywords: Higher education, educational innovative, XR, global classroom

1 INTRODUCTION
The COVID-19 pandemic highlighted the urgent need for effective remote learning solutions in higher education. In the post-pandemic era, the potential of collaborative, technology-enhanced learning experiences has become even more apparent [1]. Since 2021, experimentation with the design and development of various lessons and learning dynamics between the design department at Mälardalen University and the Industrial Engineering department at Tecnológico de Monterrey's Querétaro campus has borne fruit during the February-June and August-December 2024 semesters. During the August-December semester, the University of Seville's Industrial Engineering department joined this collaborative effort.

This paper focuses on the integration of XR lessons, gamification, AI, and storytelling to create engaging and impactful learning environments for university students. The research and practical applications of these approaches are examined, with a particular emphasis on the collaborative work between Mälardalen University, Sevilla University and Tecnologico de Monterrey.

2 DEVELOPMENTS
The integration of XR (Extended Reality) technology in engineering education within university programs offers numerous benefits but also presents certain disadvantages. XR technology provides immersive, interactive learning experiences that can enhance students' understanding of complex concepts and foster greater engagement [2]. For instance, students can visualise and manipulate 3D models of engineering structures, leading to a deeper comprehension of spatial relationships and mechanical functions [3]. Moreover, XR allows for remote access to laboratory simulations, thereby expanding the opportunity for hands-on learning regardless of geographical constraints. On the other hand, adoption of XR technology also has its downsides. The transformative shift enabled by XR places

emphasis to rethink management principles as internal processes can be affected by establishment of test-bed practices [4]. The high cost associated with developing and maintaining XR infrastructure can be prohibitive for some institutions [5]. Additionally, there may be a steep learning curve for both instructors and students in mastering the use of XR tools, potentially leading to initial disruptions in the learning process. Furthermore, prolonged use of XR devices can lead to physical discomfort or health issues, such as eye strain or motion sickness, which may affect students' overall learning experience. Balancing these benefits and drawbacks is essential for effectively incorporating XR technology into engineering curricula [6].

The joint class designs have been based on the Design Thinking and Design of Experiments methodology, presented at the 2021 E&PDE edition [7]. It was found that the following three variables measure the academic impact on students: Engagement: Measured by the time in minutes each student spends on the lesson, and the number of times they complete it. Learning: Evaluated through a pre-test and post-test using a database of 50 questions and a 20-item exam to reduce the likelihood of students having the same exam. Competency Development: Assessed through an essay presented by the student, evaluated using a rubric with 5 levels: Outstanding, Solid, Good, Sufficient, Insufficient.

During the pandemic, with the first virtual labs development, it was determined that the critical variable was engagement. Students had to complete a remote lesson because they had to do it, but not because they enjoyed it. Observing the high amount of time spent on video games, whether on mobile devices, online, or board games, it was decided to orient lesson design towards gamifying simulators and ensuring the development of digital twins, the first step is the digitalisation of the Meccano devices and the traction system and, after 3D modelling in Autodesk Fusion 360, finally the development of the XR lesson, had an environment similar to a video game. Class design included a measurable output variable, allowing students to compete. For example, car assembly was timed in seconds, and students, individually or in teams, received higher grades based on their performance relative to classmates [1].

The next component was lesson design. A problem situation was always presented through a story allowing students to immerse themselves fully and assume the role of the person seeking to solve the problem. All team of professor for both universities, defined that the lesson lifecycle should have the following stages: Problem Situation Statement, Analysis Problem Definition, Solution Strategy, Design Strategy, Interaction in Simulators Continuous Improvement through Research and Knowledge, Inference to Increase Scores, Teacher Feedback.

For designing these lessons among professors from the three universities, the experience was termed Global Classroom [8]. The MXREP simulator, which emulates car assembly behaviour, was used and connected to augmented reality lessons on the TEC-XR virtual plant platform. This app for mobile devices allows interaction with different augmented reality lessons designed by the Tecnológico de Monterrey's Education Innovation R&EIT team, with the option for students to visit their university's virtual reality lab to enhance the assembly experience using lessons designed by R&EIT and installed at the University of Seville and Mälardalen University.

For lessons at the Tecnologico de Monterrey in conjunction with Mälardalen University, the focus was on redesigning the traction system of a car built with Meccano parts. The problem involved a change of supplier from Europe to a new, lower-cost one in Mexico, causing traction issues with high production and customer complaint incidences. Students at Mälardalen University focused on solving the design problem affecting the situation, while Tecnologico de Monterrey students evaluated the negative impact of producing a component with quality issues and the economic assessment of relocating the supplier project.

For the global classroom between the University of Seville and Tecnologico de Monterrey, the problem situation focused on increasing demand for F1 and Jeep models. Tecnologico de Monterrey students had to analyse line capacity and consider increasing capacity through machinery purchases or tackling corporate productivity. The University of Seville managed the project to increase said capacity. Both Global Classrooms were conducted in three class sessions, where the lead professor at each university explained the problem situation according to their course theme to students from both universities. Multidisciplinary teams were formed among universities, and students coordinated to interact amongst themselves. Challenges to overcome included language barriers, different educational models, culture, and time zones.

In the design of each lesson, six prior sessions were held with the teaching team of the University of Seville and three with the teaching team of the Mälardalen University (the number of prior sessions was lower because work was done continuously for two years to improve the design of the interaction with

the students by carrying out pilot tests). The importance of the design lies in analysing the study plans and finding a session where there is an intersection among the syllabus of each subject or training unit. Based on the library of AR and VR lessons, the aim was to adapt them to the learning objective, and if necessary, AR lessons were designed to complement the learning.
Once the Global Classroom is designed, minute-by-minute planning of interaction with the students is carried out, along with a risk analysis of all class steps, to have contingency plans. Some activities, such as team formation, were done in advance to avoid losing time, while other activities must be carried out during the class. Institutional platforms such as Zoom for remote lessons and Teams for team interaction and document repository were used. Three impact variables in the class were measured: the development of learning through a pre-test and a post-test of the lesson, the development of competencies in the evaluation via the rubric of the essay submitted by the teams, and engagement through the measurement of the time each student spends on AR and VR lessons. Figure 1 shows the sequence of steps in the application of the Global Classroom, starting with the class design and equipment testing in the laboratories by the teaching team of each university, the design of support lessons based on virtual reality on the EON platform, and finally the interaction of students with the lessons and total immersion in class.

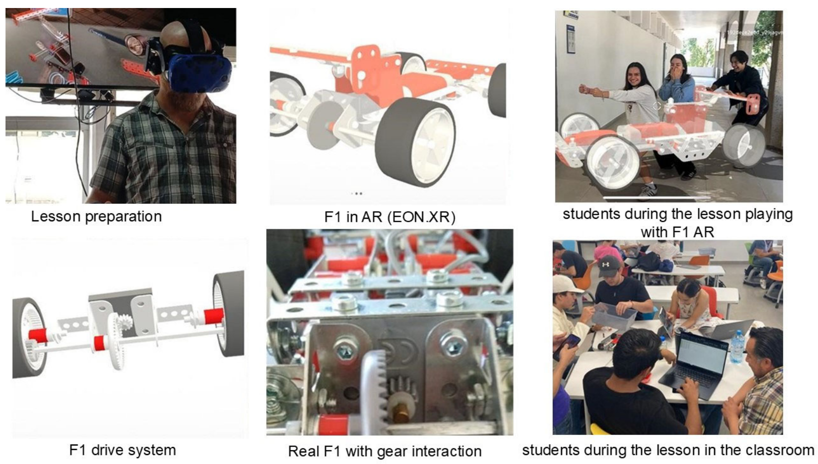

Figure 1. Design Process of the International Classroom and the student's interaction

2.1 Gamification and Engagement

Gamification has emerged as a powerful tool for increasing student motivation and engagement [6], [9], [10]. By incorporating game-like elements such as points, badges, leaderboards, and challenges, educators can create a more interactive and enjoyable learning experience. The common research interest between Tecnologico de Monterrey and Mälardalen University has demonstrated the effectiveness of gamification in the context of XR-based learning, where students are immersed in simulated environments and tasked with solving real-world problems.
The gamification component is integrated with the MxREP simulator, which enables students to modify parameters after analysing AR and VR lessons. This is facilitated by a scoring system that rewards the team with the best organisational performance. It has been observed that taking the best photo during the lessons is also a competition component. Similarly, virtual reality lessons are approached as a tournament to determine the fastest student in assembling a car. To achieve this, students must modify assembly processes, ensuring they remain valid. This constitutes an indirect method of learning.

2.2 XR Lesson and Immersive Learning

XR technologies, including virtual reality (VR) and augmented reality (AR), offer unique opportunities for creating immersive and interactive learning experiences [3], [11]. VR allows students to enter fully simulated environments, while AR overlays digital information onto the real world. Both technologies can be used to create engaging and realistic scenarios that promote active learning and problem-solving. Sevilla University, Mälardalen University and Tecnologico de Monterrey have designed and implemented XR lessons for engineering students, utilising platforms like the MXREP simulator and TEC-XR virtual plant to provide hands-on experience in areas such as automotive assembly and design.

2.3 AI and Personalised Learning

Artificial intelligence (AI) has the potential to personalise and enhance the learning process [7]. AI-powered systems can analyse student data to identify areas where they may be struggling and provide targeted feedback and support [1]. AI can also be used to create adaptive learning environments that adjust the difficulty of the material based on student progress [9]. While still in its early stages, the integration of AI into XR-based learning holds great promise for improving learning outcomes.

Databases were designed to capture interactions within both the simulator and the Virtual and Augmented Reality lessons of the Tec XR platforms. This was implemented with the aim of applying artificial intelligence to suggest parameters to students across various scenarios, thereby enhancing their scores and facilitating the discovery of viable and feasible solutions to the posed challenges. While the use of the simulator and XR lessons is provided at no cost, the design of the activity and the data generated become the property of Tecnológico de Monterrey. This ownership enables the analysis of the data and the application of generative artificial intelligence to develop improved lessons and models.

2.4 Storytelling and Contextualising

Storytelling is a powerful tool for making learning more engaging and memorable [8]. By framing learning activities within a compelling narrative, educators can create a sense of purpose and motivation for students. Team Professors belonging to the three universities have emphasised the importance of storytelling in their "Global Classroom" project, where students from different universities collaborate to solve real-world engineering challenges. The use of storytelling helps to contextualise the learning activities and make them more relevant to students' lives and future careers.

Universities may acquire the most advanced simulators and develop the finest XR lessons, but without a compelling narrative that captivates students and ignites intellectual curiosity, academic activities are destined to fail. The narrative must be crafted to pursue an objective that engages students in embodying the character and seeks complete immersion to resolve the case optimally, fostering enjoyment of the lesson rather than perceiving it as a waste of time. Consideration must be given to the cultural contexts of both universities, the characteristics of their academic programs, and the articulation of the narrative in a language that is appealing to students while maintaining academic formality. The success and failure of lessons implemented over the past two years in Global Classrooms have been primarily determined by the narrative underlying the academic activity.

3 RESULTS

Data collection from the experimental lessons indicated a substantial increase in student engagement measured by time spent and completion frequency. The competency development assessed through essays demonstrated notable improvements across various levels, reflecting the students' ability to apply their learning practically. The research and practical applications of gamification, XR lessons, AI, and storytelling in higher education have yielded promising results. The "Global Classroom" project has shown the potential of international collaboration and technology-enhanced learning to prepare students for the challenges of the 21st century.

Pre-test and post-test results showed significant knowledge gains, validating the effectiveness of XR lessons and gamification. The statistical results are shown by applying a pre-test on knowledge of line capacity analysis, project evaluation, and agile project management to students from the University of Seville and the Tecnologico de Monterrey. As seen in Figure 2a, most of the data are skewed to the left with a low average. The exam had 20 items generated from a database of 50, aiming to minimise the risk of cheating or having identical exams. After conducting the Global Classroom, it can be observed in figure 2b, that the majority of students achieved a maximum score of 100 on an exam consisting of 20 questions using the same database of 50 as in the pre-test. By applying the paired t-test, it is observed that the hypothesis that learning without Global Classroom experience and learning based on immersive technologies with a global component are the same in students is rejected. A t-value of -8.99 is observed, with a p-value of 3.7682E-09 and 95 % of confidence level there is sufficient evidence that the Global Classroom experience with immersive learning based on XR technologies in a global environment generates better knowledge among students than without Global Classroom experience.

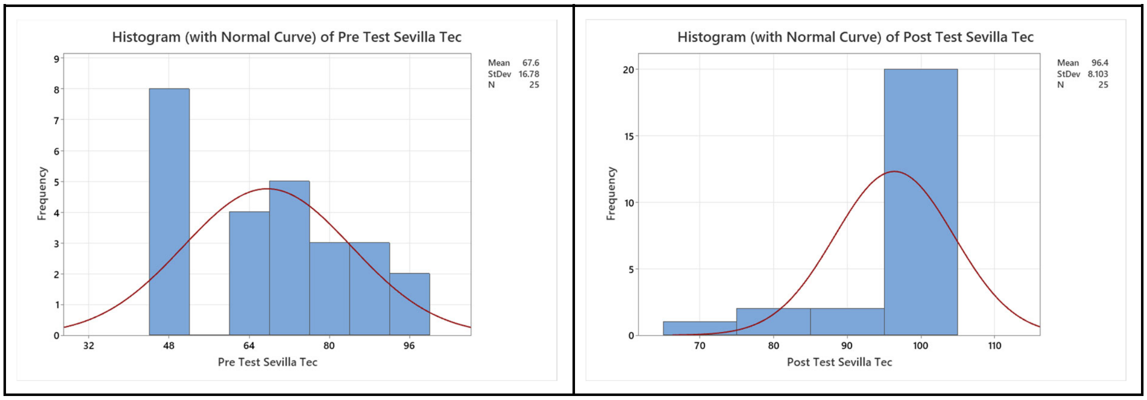

Figure 2a & 2b. Descriptive statistics protocol applied to the Sevilla & Tec Global Classroom

4 CONCLUSIONS

Gamification, XR lessons, AI, and storytelling are powerful tools for enhancing learning in higher education. By combining these approaches, educators can create immersive, engaging, and personalised learning experiences that promote student success. The integration of gamification, XR lessons, AI, and storytelling in higher education represents a significant step towards creating more engaging, effective, and personalised learning experiences for students. While challenges remain in terms of implementation and assessment, the potential benefits of these approaches are clear. As technology continues to evolve, it is expected to see even more innovative applications of these techniques in the years to come.

Designing a Global Classroom is not a simple task; it begins with the willingness of two teaching teams to seek commonalities across different academic programs and educational models, each based on the specific contexts of their respective countries. Factors such as language, time zone differences, and student expectations pose additional challenges. Aligning diverse objectives into a common learning goal is only achievable through discipline, commitment, and a solid methodological approach. The collaborative experience among the three universities has yielded significant learning opportunities to enhance these models, develop competencies, and increase student engagement. Documenting best practices and designing action plans to address areas of improvement will ensure that these Global Classrooms become foundational elements in distance learning and collaborative models between universities.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial and technical support of the Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this Work. The authors would like to acknowledge the financial support of Novus Grant with PEP No. 2023- 425360, TecLabs, Tecnologico de Monterrey, Mexico, in the production of this work.

REFERENCES

[1] Hall G., Laddu D. R., Phillips S. A., Lavie C. J. and Arena R. A tale of two pandemics: How will COVID-19 and global trends in physical inactivity and sedentary behaviour affect one another? *Progress in cardiovascular diseases*, 2021, 64, pp. 108-110.

[2] Berglund A. Design for extended reality (DfXR)–Exploring engineering and product design education in XR. In DS 123: *Proceedings of the International Conference on Engineering and Product Design Education (E&PDE 2023).* Elisava, Barcelona School of Design and Engineering, 2023, September 6-8. 10.35199/EPDE.2023.60

[3] Gonzalez Almaguer C. A., Acuña López A., Pérez Murueta P., Aguirre Acosta Á. C., Román Jiménez O. R. and Zubieta Ramírez C. Virtual and Augmented Reality to Exploit Stem-Skills-Based Learning for Engineering Students using the TEC21 Educational Model. In DS 110: *Proceedings of the 23rd International Conference on Engineering and Product Design Education (E&PDE 2021)*, VIA Design, University in Herning, Denmark, 2021, September 9-10. 10.35199/EPDE.2021.74.

[4] Berglund A. Adopting Extended Reality: Navigating Structures, Processes and Resources, *ICERI2024 Proceedings*, 2024, pp. 10312-10318. 10.21125/iceri.2024.2634.

[5] Radianti J., Majchrzak T. A., Fromm J. and Wohlgenannt I. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda, *Computers & Education*, 2020, 147, 103778. https://doi.org/10.1016/j.compedu.2019.103778.
[6] Buckley P. and Doyle E. Gamification and student motivation. *Interactive Learning Environments*, 2016, 24(6) pp. 1162–1175.
[7] Gonzalez Almaguer C. A., Saavedra V., Acuña López A., Caballero Montes E., Zubieta Ramírez C., Lule M. and Barbosa E. Design Thinking and Design of Experiments: The fusion of the school of design and industrial engineering to create learning experiences in the Tec21 Educational Model. In DS 110: *Proceedings of the 23rd International Conference on Engineering and Product Design Education (E&PDE 2021)*, VIA Design, University in Herning, Denmark, 2021, September 9-10.
[8] Cortés Vásquez J., Alonso Galicia P.E., Sánchez Olmos C. and Barradas Gurruchaga A. R. A global classroom entrepreneurship and creative industries experience: Spain and Mexico - possibilities and challenges, *In Proceedings, INTED*, 2022, pp. 3690-3695.
[9] Egashira M., Son D. and Ema A. Serious Game for Change in Behavioural Intention Toward Lifestyle-Related Diseases: Experimental Study with Structural Equation Modelling Using the Theory of Planned Behaviour. JMIR Serious Games, 2022, 10(1), e28982. doi:10.2196/28982 PMID:35188465 (PDF) The Role of Gamification in a Post-Pandemic World: The Experience of China. Available from: https://www.researchgate.net/publication/372090628_The_Role_of_Gamification_in_a_Post-Pandemic_World_The_Experience_of_China [accessed Feb 04, 2025].
[10] Holloway S. Gamification in Education: 4 Ways to Bring Games to Your Classroom, 2018 (May) Available from https://tophat.com/blog/gamification-education-class/.
[11] Berglund A. Empowering XR Proficiency: Exploring Professional Case-based Learning Scenarios. *In INTED2024 Proceedings*, 2024, pp. 6821-6828. https://doi.org/10.21125/inted.2024.1793.÷